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Nanotechnology Booster for Solar Cell: Review

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ABSTRACT: In this paper discuss about the new technology i.e. nanotechnology is used to boost the radiation of the UV in the solar cells. Silicon crystalline has causes in the reflectance and reduced the efficiency of overall solar panel. The loss of reflection can be protecting by using antireflection coating (ARC). In the age of 55 years ago crystal silicon are used in the solar cell his efficiency 6% to 22% in this range. Now we will developed and reach up to 30.7%. In the age of 90's reach the efficiency level 50% with the help of some compound. US department of energy (DOE) is building technology program to improve the high performance energy efficiency. Now they are maximize the heating and cooling with the application of nano phase change material (PCM) was developed by to improve the efficiency. Efficiency of the solar cell is changing by the different factor and nonlinear loads in maximum case. Efficiency of solar cell increase when the reflection is very inclined angle increases. With the help of multi layer solar cell the abortion and scattering from the nano-particles. Nano-crystalline Ag particles homogeneously distributed with high degree of control of nano-particle. Mie theory and Maxwell-Garnet theory explained also explained. The nano coating on the solar cell will increases the abortion up to 60% of UV and IR radiation than that of silicon other material. Control of solar cell energy by using nano grid DC-DC converter.

KEYWORDS:- Solar Cells, Nano-structure, Anti-reflection coating, Nano phase change material, Nano grid DC-DC Converter

I. INTRODUCTION

Solar cells are utilized as a part of a wide assortment of uses including household supply, remote lighting frameworks, an electric power era in space and medicinal science. Presently a day, because of emergency of petroleum derivatives and genuine contamination from it, solar vitality turns into a conspicuous option. It is an inexhaustible and economical vitality source. Solar photovoltaic is an exceptionally helpful innovation since it has a capacity to change over solar vitality into electrical vitality without delivering any clamor and unsafe impact. The primary favorable position of this innovation is its low support cost. A few specialists have demonstrated their enthusiasm for the creation of various sorts of solar cells. However the diminishment of cost and upgrade of productivity is huge test. To accomplish high effectiveness, solar cell must have a decent assimilation capacity ($>10^5$) with least misfortunes amid recombination [1, 2]. By and large to design of solar cell, minimal effort materials are utilized, where they have either an abnormal state of pollutions or a high thickness of imperfections. This may cause low minority-bearer dissemination lengths which however influences the execution of the gadget. With no light-catching plans, the planar solar-cell structures with those materials like Si have no high vitality transformation efficiency [3].

It can be utilized as a compelling building hinder for the solar cell because of its capacity to gather photons and photo generated transporters in the orthogonal headings. Nano wire structures have the additional favorable position of little reflectance property over a wide range and can be accomplished without utilizing any antireflection covering. In this way optical retention upgrades essentially in the high recurrence administration yet a comparative change can't be accomplished in low recurrence administration. In light of the little termination coefficient of silicon, which is the light lost to disseminating and assimilation. However the less-ideal retention in the low-recurrence administration can be overwhelmed by utilizing long wires, or light catching [3].

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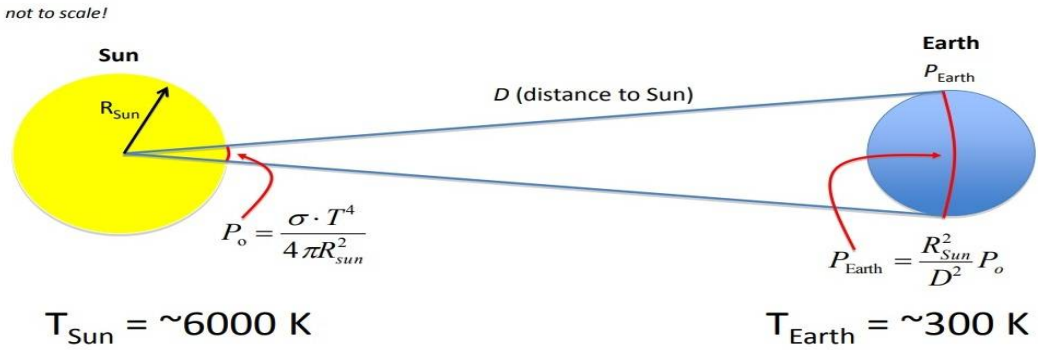

Figure 1: Max Solar Heat Engine (Blackbody) []

In the above figure (1) the temperature of Sun is ~6000K and the temperature of Earth is ~300K. If we compare the power of Sun and Earth is very high for a small angle. Solar cell estimations on booked high elevation swell flight battles have been the acknowledged technique to obtain solid solar cell execution estimations in a closet space condition. The space photovoltaic (PV) people group has beforehand recognized these estimations are imperative for evaluating the execution of the most recent space solar cell innovation and for delivering reference cells for alignment of research center solar test systems. Inflatable alignment flight crusades have not happened for over a decade, be that as it may, and a few present and rising space solar cell advancements guaranteeing execution picks up don't have exact reference gauges expected to approve those claims. Rather, look into airplane (working at bring down pinnacle elevation, ~60,000 ft) have been utilized to fly the reference cells and get estimations [4]. Experimental techniques are required to rectify in-flight estimations acquired at bring down elevations because of lessening of short wavelength solar range by environmental O3; such redresses are relied upon to turn into more basic as new space PV innovation grows to 4-, 5-, and 6-intersection cells. There has been a push to create business expand flights for solar cell adjustment ability what's more, these endeavors were as of late talked about in a workshop board [5]. Work is in advance to assess the business expand flight specialist co-ops' capacity to indeed give a solar cell swell flight alignment administration to the space PV group.

On the Silicon based type solar cell with the nano level surface trench structure will be reduces from 37% to 16% and also efficiency can be improved ~3% due to very light taping on the trench structure, very less electromagnetic wave reflection more abortion of visible light. We also proposed that advantage SiGe-based solar cell than Si-based advantage and benefits considering the cell efficiency and of the effect of the temperature [6].

Some of the other material very low cost solar cell solution thin film following: (i) Amorphous Silicon (A-Si) [7], Cadmium telluride (CdTe) [8] and Copper Indium Disslenide (CIS) [9] these are the most developed technologies (ii) thin films Silicon is cover the crystalline or amorphous type of silicon. The thin film technology uses in the PV module that will increase the efficiency at the level of commercial module, manufacturing and reliability. For thin films, the monolithic process blurs the distinction between cells and modules.

A modern phase change material (Nano-PCM) was developed with the help of expanded graphite nano-sheets of PCM i.e. highly conductive for enhanced thermal storage and energy distribution. This shape is stable suitable for incorporation into lightweight building or home type of component. [11]

PCM wallboards will be referred to using the following list.

1. PCM Soaked Gypsum
2. Three Layer Structure
3. Dispersed Nano-PCM
4. MEPCM in Gypsum (also used as a control) [11]

Be that as it may, business module efficiencies change between 5% what's more, 11%. Cost of this thin film solar cell is practically same as that of c-Si. Due to the dangerous natures of these materials and worries for the earth, thin film-based solar cells are not broadly acknowledged. The best research facility efficiencies got for different materials and innovations, by and large this is done on extremely little, i.e., one square cm, cells. Business efficiencies are essentially lower.

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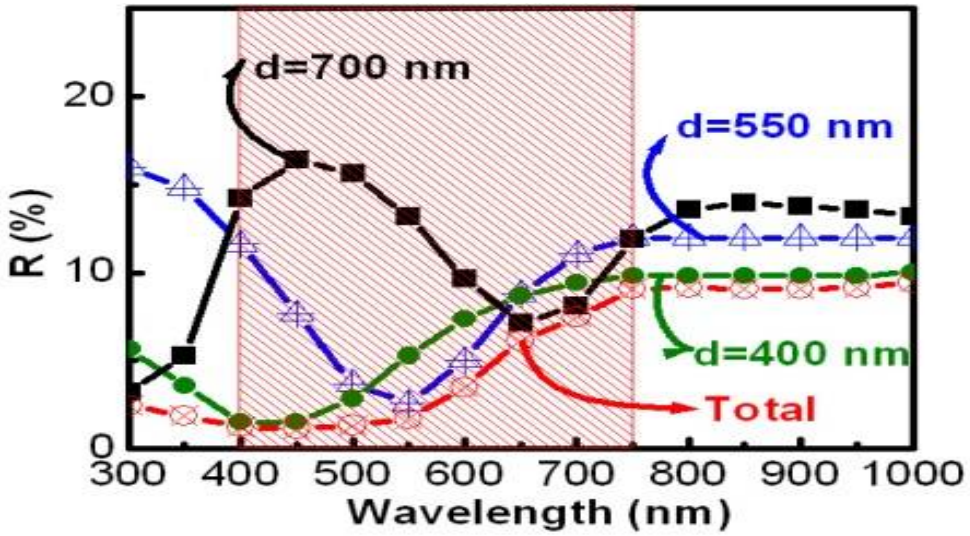

Figure: 2 The reflection spectra with different designed surface trench spacing (d) structures. With the special designed trench structure on the top surface (the range of designed spacing d is from 700 nm to 400 nm).[10]

Figure. 2 demonstrates the reflection spectra (the scope of wavelength for the noticeable light is between 400 nm to 700 nm) with various surface trench dispersing (d) structure plan. Due to the genuine application for the solar cell, the reflection rate among noticeable light area is checked and observed initially prior to the genuine solar cell productivity estimation. It can be discovered that the base in the reflectance spectra moved as a capacity of the surface trench separating (d), reliable with the limited differential time area (FDTD) figuring [10]. In fact, FDTD reproduction and hypothesis uncovered that the surface structure with littler trench separating (d) primarily assimilates short wavelength light, while the surface structure with bigger trench separating (d) primarily assimilates long wavelength light. It too demonstrates that the surface structure having distinctive trench spacing may understand broadband antireflection among the obvious district. With the blend of unpredictable surface trench dividing from 700 nm to 400 nm on the nano-meter level (appeared as red bend in Fig. 1), the broadband antireflection over the obvious light district for the solar cell application can be acknowledged and expanded. Our exploratory information demonstrate that the planned unpredictable surface trench separating can contribute bring down surface reflectance among the noticeable light locale about 3 times (absolutely from 32 % to ~10 %) and additionally prompts higher solar cell effectiveness around 3 % in this work [10].

II. NANO PHASE CHANGE MATERIAL

Solar-cell energy is for the most part put away as warmed sensible warmth. Because of time-needy and eccentric attributes of sun presentation, the proficiency of solar-warm frameworks depends on the effectiveness of warm energy stockpiling innovation. Solar-Thermal energy can be put away as dormant warmth by utilizing an appropriate Phase Change Material (PCM). This offers a higher warmth stockpiling limit per volume/mass and a higher temperature steadiness of put away heated water. Use of solar-warm energy stockpiling tanks with PCM based dormant warmth stockpiling innovation is required to improve the efficiency of accessible solar-warm frameworks. The higher proficiency is accomplished by conquering any hindrance between solar warmth accessibility and boiling water request. Phase Change Material (PCM) retains warm amid its stage change cycle from strong to fluid amid the daytime solar cycle. The measure of warmth that a tank of water can ingest is considerably higher with the nearness of stage change material. Save energy PCM58P is a non-lethal and non-combustible, inorganic PCM, that can be exemplified in 75mm polypropylene or high thickness polyethylene balls. They are then added to protected, environmental coating of anti-reflection glass. This PCM works from 52 degrees C to 63 degrees C (126 degrees F to 145 degrees F) with a stage change temperature of 55 degrees C to 59 degrees C (131 degrees F to 138 degrees F). Idle warmth stockpiling

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innovation likewise decreases water temperature variances in solar warm framework as PCM settles temperatures [14]. In the figure (3) show that for ideal work of PCM the store heat in this material. It is likely to increases the sun temp the heat produced by the PCM in solar cell system is increases and that will produce the more power or energy. At the point of temperature phase change the store heat is constant.

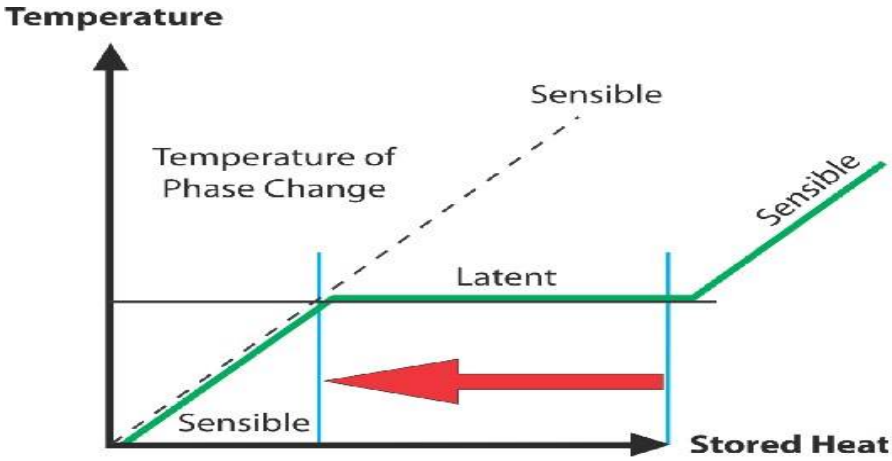

Figure: 3 Ideal graph for the range of the solar heat control change with the temperature

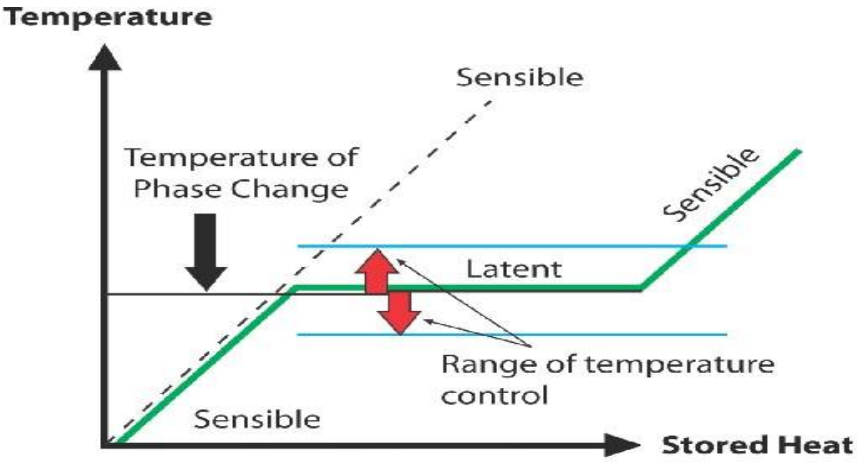

Figure: 4 Ideal graph for the solar heat change with the range of the temperature control

In the figure (4) show that the range of the temperature control from the point of the temperature of phase change for the interval in latent stored heat energy of the solar cells.

Microencapsulation of CaCl2.6H2O in polyester tar was especially fruitful, and the improvements of divider and floor boards were examined. Microencapsulation of CaCl2.6H2O in plastic film compartments seems promising for warming frameworks utilizing air as the warmth exchange medium. He has surveyed the specialized and financial plausibility of utilizing epitomized PCMs for warm vitality stockpiling in sun based driven private warming applications and has created methods for exemplifying a gathering of promising stage change warm capacity materials in metal.

Commercial paraffin waxes are cheap with moderate thermal storage densities (200 kJ/kg or 150 MJ/m3) and a wide range of melting temperatures. They undergo negligible sub-cooling and are chemically inert and stable with no phase segregation. However, they have low thermal conductivity (0.2 W/m C), which limits their applications [17]. In the table (1) there are some type of PCM are shown with their phase change temperature with the density and latent heat. Also their physical state of PCM that are used application given below.

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TABLE 1 OF PHASE CHANGE MATERIALS (PCM) SPECIFICATIONS [14]

Application	PCM	Phase Change Temperature (°C)	Phase Change Temperature (°F)	Density(Kg/cu.m)	Latent Heat(KJ/Kg)	Physical State@ 25°C
Frozen	PCM-HS26N	-26	-15	1200	205	Liquid
	PCM-HS23N	-23	-10	1180	200	Liquid
	PCM-PDR15N	-12	+10	570	138	Powder
	PCM-HS10N	-10	+14	1100	220	Liquid
Refrigerated	PCM-PDR03P	+3.5	+38	570	185	Powder
	PCM-OM06P	+5.5	+42	735	252	Liquid
Ambient	PCM-PDR15P	+15	+59	570	154	Powder
	PCM-OM18P	+18	+65	735	233	Liquid
	PCM-HS22P	+22	+72	1540	185	Liquid
Incubation	PCM-OM37P	+37	+99	880	218	Solid
Hot	PCM-OM65P	+65C	+149	840	210	Solid

Key advantages of PCM based latent heat storage for solar-thermal systems:

- Temperature of stored water decreases at a much slower rate.
- PCM can pre-heat cold inlet water during extreme consumption of evening hours.
- Total heat storage is more efficient with PCM in solar-thermal storage tanks.

Inorganic PCM are built hydrated salt arrangement produced using normal salts with water. The concoction creation of salts is differed in the blend to accomplish required stage change temperature. Unique nucleating operators are added to the blend to limit stage change salt partition and to limit super cooling, that are generally normal for hydrated salt PCM. Salt Hydrates are normal for being non-harmful, non-combustible and sparing.

Bio-based PCM are natural materials that are normally existing unsaturated fats, for example, vegetable oil. In view of their substance organization, their stage change temperature can differ. These items are non-harmful, non-destructive and have unbounded life cycles. They however can be costly and combustible at high temperatures.

Organic PCM are normally existing oil bi-items that have their extraordinary stage change temperature. These items are produced by significant petrochemical organizations so their accessibility could be restricted. They can be lethal, combustible and costly. They have endless life cycles and the cost differs with changes in oil costs all inclusive.

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ADVANTAGES OF PHASE-CHANGE ENERGY STORAGE

- Store warm energy at the temperature of process application
- Store warm energy as dormant warmth which permits higher warm energy stockpiling limit per unit weight or material with no adjustment in temperature
- Tore warm energy from warm energy source or electrical energy source when accessible and utilize when required
- Tore warm energy is compact and rechargeable

ECONOMICAL & ENVIRONMENTAL BENEFITS

- Store natural thermal energy for facility heating and cooling needs. Reduced energy demand reduces facilities carbon footprint
- Store thermal energy during off demand hours and use during peak demand to save on energy cost and help stabilize grid load
- Shift of heating and cooling load also reduces peak time stress of heating and cooling equipment that can lead to reduced operating & maintenance cost.
- This technology would lead to sizing HVAC equipment for average load rather than peak load

PCM are the non-toxic, inorganic and organic product in engineering for the storage of thermal energy. Energy store as a compounding of sensible and latent heat. During the process of the absorbed or release energy while the temperature at phase change remains constant. The phase change materials is the unique capability to store the thermal energy and to control the temperature at phase change [14].

III. NEW PCM TECHNOLOGY INNOVATIONS

Another technique for satellite power testing utilizing PCMs. Central to the sun oriented power framework (Solar Power) are arrangement of metal cells contain a PCM that is fluid under high temperature, which at that point solidifies amid hours of icy dimness, discharging its dormant warmth. The warmth discharged can at that point be utilized to produce power by driving thermoelectric units. Since the frameworks produce no less than three times more power than batteries of equivalent size, they are viewed as a conceivable contrasting option to traditional satellite sun based power frameworks that depend on batteries [15]. By having a hot converter toward the begin of an outing, auto discharges, for example, hydrocarbons and carbon monoxide, can be diminished drastically by up to 80%. NREL wrapped its reactant converter in conservative vacuum protection to keep it at an effective working temperature for up to 24 h after the motor is closed off. An exhaust system was created by utilizing PCMs to retain, store and discharge warm as required [18]. Having outlined a novel ventilation evening time cooling framework (a novel mix of PCM and warmth funnels) as another option to aerating and cooling. The framework offers considerable benefits regarding diminishing or taking out the requirement for aerating and cooling and in this way essentially decreasing CO2 emanations and sparing vitality in structures [15]. Particles of microencapsulated PCM (3– 100 lm) as well as microencapsulated PCM (1– 3 mm) can be incorporated inside material strands, composites, attire to give significantly upgraded warm security in both hot and icy situations [16]

IV. DC-DC CONVERTER

Nano grid is self-controlled substances and worked in either grid-associated or island mode, which interconnect neighborhood DERs what's more, loads with neighborhood circulation frameworks [19]. The fundamental preferred standpoint of a DC Nano grid is that it gives a superior consistence with DC sorts of DERs and burdens [20-21]. For case, solar PV and battery stockpiling would just use a DC/DC change in DC Nano grid which gives an easier what's more, taken a toll effective structure with a considerably simpler control system. The Nano grid idea delineates these issues by partner a assortment of circulated energy sources and loads in a power organize equipped for an islanding operation with the primary grid [22]. The arrangements of Nano grids are required to affect the financial, ecological power supply quality and dependability angles [23]. Nano grid allude to a little size of the power organize, with voltage levels utilized on the circulation arrange (≤20 kV) and power evaluations going up to 1 MW [24].

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V. CONCLUTION

Organic and inorganic mixes are the two most normal gatherings of PCMs in solar cells. Generally Organic PCMs are non-destructive and synthetically steady, show close to nothing, are good with most materials and have a high idle warmth for each unit to deliver electrical energy. Their hindrances are low warm conductivity, high changes in volume on stage change and combustibility. Inorganic mixes have a high inactive warmth for every unit volume and high warm conductivity and are non-combustible and low in cost in contrast with Organic mixes. Be that as it may, they are destructive to most metals and experience the ill effects of disintegration, which can influence their stage change properties. The uses of inorganic PCMs require the utilization of nucleating and thickening specialists to limit sub-cooling and stage isolation. Critical endeavors are proceeding to find those specialists by business organizations. The applications in which PCMs can be connected in the a large number of the application like warmth and coolness stockpiling in structures to warm capacity in satellites and defensive attire and so on. A PCM with an effectively flexible warming point would be a need as the warming point is the most essential foundation for choosing a PCM for latent solar applications. Numerous more applications are yet to be found. Diverse set focuses were utilized as a part of the reenactments to assess their effect on the outcome diminishments in the outer warmth misfortune space-molding loads due to the PCM. Decreases of 4.9-23.5% and 4.9-44.8% in ascertained warmth additions and misfortunes, individually, were watched for the diverse divider introductions, with 20-23.3°C inside temperature set focuses. The decrease in the cooling power use with the PCM was touchy to inside set focuses and the most noteworthy lessening (13.4%) was seen at 19-21°C.

REFERENCES

[1] Yinghuan Kuang, Karine H. M. Van der Werf, Z. Silvester Houweling, and Ruud E. I. Scrap, " Nanorod solar cell with an ultrathin a-Si: H absorber layer," Applied physics letters, vol. 98, pp. 113111, 2011.
[2] M.J.M. Pathak, K.Girotra, S.J.Harrison, J.M. Pearce, "The effect of hybrid photovoltaic thermal device operating conditions on intrinsic layer thickness optimization of hydrogenated amorphous silicon solar cells", Solar Energy, vol. 86, pp. 2673-2677, 2012.
[3] Xiaocheng Li, Beng Kang Tay, Philippe Miele , Arnaud Brioude, David Cornu, "Fabrication of silicon pyramid/ nanowire binary structure with superhydrophobicity,''Applied Surface Science, vol. 255, pp. 7147-7152, 2009.
[4] Justin H. Lee, John C. Nocerino, Brian S. Hardy, David A. Hinkley, Daniel L. Rumsey, Peter J. Carian, Simon H. Liu, Don Walker, John F. Morales, Darren W. Rowen, David P. Arndt, Geoffrey A. Maul, Richard P. Welle, Petras Karuza, Siegfried W. Janson, John P. McVey, Joseph W. Gangestad, Colin J. Mann, and Yao Yue "On-Orbit Characterization of Space Solar Cells on Nano-satellites" The Aerospace Corporation, El Segundo, CA, 90245, USA
[5] Lee, J. H. and D. Walker (2015), *Panel Discussion on High Altitude Solar Cell Testing*, Space Power Workshop, Manhattan Beach, California.
[6] C.-F. Hsieha, H.-S. Wua, T.-C. Wua and M. H. Liaob, "Solar Cell Composed of Periodic Nano-Structure and SiGe/Si Thin Film" 978-1-4799-3299-3/13/2013 IEEE
[7] K. Yamamoto, M. Yoshimi, T. Suzuki, Y. Tawada, T. Okamoto, A. Nakajima,. "Thin film poly-Si solar cell on glass substrate fabricated at low temperature". Presented at MRS Spring Meeting, San Francisco, April 1998.
[8]] X. Wu, J. C. Keane, R.G. Dhere, C. DeHart, A. Duda, T.A. Gessert, S. Asher, D. H. Levi, P. Sheldon, "16.5%-efficient CdS/CdTe polycrystalline thin-film solar cell", Proceedings of the 17th European Photovoltaic Solar Energy Conference, Munich, 22–26, October 2001; 995–1000.
[9] M. A. Contreras, B. Egaas, K. Ramanathan, J. Hiltner, A. Swartzlander, F. Hasoon, R. Noufi, "Progress toward 20% efficiency in Cu(In,Ga)Se polycrystalline thin-film solar cell", Progress in Photovoltaics: Research and Applications 1999; 7: 311–316.
[10] C.-F. Hsieha, H.-S. Wua, T.-C. Wua and M. H. Liaob "Solar Cell Composed of Periodic Nano-Structure and SiGe/Si Thin Film" 978-1 4799-3299-3/13/©2013 IEEE
[11] Kaushik Biswas, Phillip Childs, Jerald Atchley "FIELD TESTING OF NANO-PCM ENHANCED BUILDING ENVELOPE COMPONENTS" Energy and Transportation Science Division,ORNL/TM-2013/207
[12] KingaPielichowska, KrzysztofPielichowski "Phase change materials for thermal energy storage"
[13] ZhihuaZhou, ZhimingZhang, ianZuo , KeHuang ,LiyingZhang "Phase change materials for solar thermal energy storage in residential buildings in cold climate"
[14]Save Energy Phase Change Material website [www.rgees.com]
[15] Revankar S. Purdue University News Bulletin, 2001. Available from: <http://news.uns.purdue.edu/UNS/html4ever/010607.Revankar.solar.html>.
[16] John T, David E, David R. "A novel ventilation system for reducing air conditioning in buildings: Testing and theoretical modeling", Appl Therm Eng 2000;20:1019–37.
[17] Mohammed M. Farid a,*, Amar M. Khudhair a, Siddique Ali K. Razack b, Said Al-Hallaj "A review on phase change energy storage: materials and applications" doi:10.1016/j.enconman.2003.09.015
[18] NREL Web Site [www.ctts.nrel.gov/bent]
[19] E. Koutroulis, K. Kalaitzakis, and N. C. Voulgaris, "Development of a microcontroller-based, photovoltaic maximum power point tracking control system," *IEEE Trans. Power Electron*., vol. 16, no. 1, pp. 46–54, Jan. 2001.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An UGC Approved Journal)

Website: www.ijareeie.com

Vol. 6, Issue 8, August 2017

[20] L. Che, and M. Shahidehpour, "DC Micro grids: Economic Operation and Enhancement of Resilience by Hierarchical Control", *IEEE trans. on smart grid*, vol. 5, no. 5, pp. 2517-2526, Sep. 2014.
[21] J. Schonberger, R. Duke, and S. D. Round, "DC-bus signaling: A distributed control strategy for a hybrid renewable Nano grid," *IEEE Trans. Ind. Electron*., vol. 53, no. 5, pp. 1453–1460, Oct. 2006.
[22] T. Dragicevic, J. M. Guerrero, J. C. Vasquez, and D. Skrlec, "Supervisory control of adaptive-droop regulated DC micro grid with battery," IEEE Trans. Power Electron., vol. 29, no. 2, pp. 695–706, Feb. 2014.
[23] J. Ping, Z. X. Xin, and W. Shouyuan, "Review on sustainable development of island micro grid," in Proc. 2011 *IEEE Int. Conf. Advanced Power System Automation and Protection (APAP)*, vol. 3, pp. 1806–1813, Oct. 2011.
[24] C. Cho, J. H. Jeon, J. Y. Kim, S. Kwon, K. Park, and S. Kim, "Active synchronizing control of a micro grid," *IEEE Trans. Power Electron.*, vol. 26, no. 12, pp. 3707–3719, 2011.